ECOSYSTEM SCIENCE

Panel Manager - Dr. Edith B. Allen, University of California, Riverside
Program Director - Dr. Cindy Huebner

The Ecosystem Science Program is designed to increase our understanding of interactions between abiotic and biotic components of populations, communities, ecosystems, and landscapes. This basic information is essential to assess environmental conditions and the sustainability of agriculture within an ecosystem context. Research on the structure, function and sustainability of forest, rangeland, crop, or aquatic (including riparian, wetland, and estuarine areas, but not oceanic) ecosystems is supported. Results provide better information and tools for agricultural planning, evaluating the effects of agricultural practices on environmental quality and sustainability, and characterizing the functional integrity of natural ecosystems.

2000-00706 Effects of Plant Functional Diversity on Ecosystem Nitrogen Retention Following Fire

Mack, M. C.
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Postdoctoral Felowship; Grant 2001-35101-09874; $90,000; 2 Years

Recent climate warming trends and an increase in human activities have led to documented increases in fire occurrence in North American and Eurasian boreal forests. Forest productivity in the boreal biome is generally nitrogen (N) limited and increased fire frequency causes increased opportunities for N loss from these ecosystems via combustion and post-fire losses to the atmosphere and aquatic systems. Understanding controls over post-fire N losses is important for predicting the long-term consequences of an altered fire regime for forest productivity, and carbon (C) cycling and sequestration. In this proposal, it is hypothesized that the species of plants that initially colonize the burned ecosystem will control the ability of the ecosystem to accumulate C and thus retain N following fire. This hypothesis will be tested with a study of N losses following fire in a boreal black spruce (*Picea mariana*) forest near Fairbanks, Alaska, that burned in June 1999. The research approach will consist of an ecosystem scale ^{15}N labeling study combined with experimental manipulation of plant species composition. This approach will test explicit hypotheses about the effects of plant species and plant diversity on ecosystem C accumulation and N retention. The proposed research will provide a mechanistic framework for understanding the relationship between plant species diversity and the functional response of the ecosystem to disturbance. Furthermore, this project will extend understanding of controls over long-term productivity of boreal forest in the context of climate change and altered disturbance regime.

2000-00775 Land-Use Change in Central Colorado: Ecosystem Consequences of Urbanization

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Postdoctoral Fellowship; Grant 00-35101-9361; $90,000; 2 Years

Land-use change may be the single most important way that humans impact ecosystems. Urbanization, the conversion of native and agricultural ecosystems to urban ecosystems, is a widespread type of land-use change that has received little attention from ecosystem ecologists.

In central Colorado, urban land occupies more than 50% of the landscape and cities continue to grow rapidly throughout the region. Most of the new urban land is derived from the conversion of agricultural land. The main objective of my proposed research is to estimate how the conversion of agricultural land to urban use affects carbon and nitrogen cycling in central Colorado. This region is well suited for the study because it maintains a nationally important agricultural economy adjacent to an urban metropolis and intact native ecosystems. This situation allows for an unplanned experiment in which managed land-use types can be experimentally compared to unmanaged (native) control ecosystems. I will measure inputs, outputs, and storage of carbon, nitrogen, and water in 5 common ecosystem types in central Colorado: (1) native shortgrass steppe, (2) irrigated corn crops, (3) dryland wheat crops, (4) urban lawns and parks, and (5) impermeable urban ecosystems. I will then link these field-based measurements with a regional land-use database to determine the effect of urbanization on element cycles during the past 5 decades. Finally, I will use a simulation model to determine whether simulated climate change or land-use change has a greater effect on regional carbon and nitrogen cycles.

2000-00690 Influence of Cattle Grazing and Land Use on Freshwater Wetlands in Rangeland Ecosystems

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Grant 00-35101-9282; $267,300; 2 Years

Wetlands embedded in agricultural landscapes are extremely important because of their role as wildlife habitat and their capacity to assimilate nutrients. Despite their recognized importance, little is known about how wetlands respond to nutrient enrichment, disturbance, or changes in land use and agricultural practices. Many wetlands are exposed to grazing livestock but few studies have examined interactions between wetland ecosystems and grazing animals. It is imperative to understand the role of grazing animals in wetlands given the extent of wetlands that are exposed to livestock and the value of wetlands as nutrient sinks and wildlife habitat. The proposed research will evaluate the effects of cattle grazing and associated land use on seasonal wetlands of south central Florida, where extensive subtropical rangelands intersect with some of the most sensitive wetland ecosystems in the United States. The objectives are to examine the influence of grazing cattle and grazing land use on nitrogen and phosphorus cycling, biological productivity, and associated ecological characteristics in seasonal wetlands of subtropical ecosystems. The experimental approach involves a large-scale experiment in which cattle are stocked at four different densities in two different land use types: improved and semi-native pastures. The proposed research will make significant contributions toward understanding wetland nutrient dynamics in subtropical rangelands, a unique, but poorly studied component of the nation's rangeland resources. Results stemming from this work will enhance our understanding of nutrient retention in these systems and may be applicable, in general, to effective management of wetland ecosystems exposed to grazing livestock.

2000-00691 Nitrogen Controls on Belowground Carbon Allocation and Fates at Ecosystem Scales

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Grant 00-35101-9283; $400,000; 2 Years 6 Months

The manner in which carbon (i.e., energy) allocation is controlled by resource (e.g., water, nutrients, and light) availability is among the most pressing questions facing terrestrial ecosystem ecologists today. Advancements in this area have been hindered primarily by a poor understanding of fine root (i.e., small, feeder roots that have relatively short life spans) dynamics. This study will address nitrogen controls on fine roots in forests since (i.) forests have large carbon storage potentials and occupy vast areas, and (ii.) nitrogen is generally the most limiting nutrient to plant production in forests. The primary objectives of this study are to (i.) investigate nitrogen controls on fine root processes such as production, respiration, senescence, and herbivory, and (ii.) test competing hypotheses regarding nitrogen controls on carbon allocation and plant production. A randomized factorial experimental design that manipulates carbon source to roots (via foliage removal), carbon fates in roots (via nitrogen fertilization), and root herbivory (via insecticide application) will be used to advance a more comprehensive and mechanistic understanding of the patterns and controls of production in forests. Also, two new techniques that avoid the major limitations of conventional approaches, the minirhizotron video image analysis system and the ^{15}N isotope tracer technique, will be used to assess root dynamics. These investigations may provide insight into the role of fine roots in the structure and function of forest ecosystems which is critical to understanding the ecology of forests, managing them in ecologically sound ways, and modeling their responses to changing environmental conditions.

2000-00780 Minimizing the Impacts of Herbivory in Forest Regeneration: A Test of Localized Management

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Grant 00-35101-9284; $275,00; 4 Years

Browsing by white-tailed deer in Eastern deciduous forests can have profound impacts on stand structure, composition, and biodiversity. Because traditional management strategies have not always prevented overbrowsing of regenerating forests, our study evaluates an alternative management strategy of an overabundandant deer population in central West Virginia. Our long-term goal is to determine the effectiveness of localized management in forest regeneration areas. Specifically, our objectives are to investigate the movement ecology and social structure of white-tailed deer in these extensive forest areas, and then use this data to design and conduct an experimental removal of a social group in the vicinity of regeneration areas. We will monitor the responses of adjacent social groups and quantify the vegetation response in the regeneration area before and after removal. Our study will use an intensive radio-telemetry effort to delineate social groups, as well as genetic analyses of relatedness among individuals. Selectively removing social groups around regeneration areas may cause (1) a persistent zone of low deer density; (2) a localized reduction in deer browsing pressure; (3) enhanced seedling reestablishment, and (4) an increase in tree recruitment. If successful, this alternative management strategy may allow managers to ensure regeneration success, sustain forest structure, and maintain biodiversity.

2000-00782 Forest Dynamics Across a Soil Resource Gradient: A Mechanistic and Modeling Approach

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Grant 2001-35101-09840; $285,000; 3 Years

Human activity is modifying three principle factors that affect the species composition and productivity of southern New England forests. They are (i) increases in the deposition of N from atmospheric sources (e.g., rainfall and particulate matter), (ii) decreases in the deposition of Ca from atmospheric sources, and (iii) changes in climate, notably precipitation. Because forests are composed of organisms that are long-lived, the effects of these changes on forest composition are often difficult to observe directly. This research will try and determine how and why changes in nitrogen availability, calcium availability, and/or precipitation will affect the composition of forests in the future. This will be achieved by conducting a field experiment located along a gradient in nitrogen, calcium and water availability and with additions of each of these resources into a series of experimental plots on three sites along the natural gradient. Seedlings of four species (sugar maple, red maple, white pine, red oak) will be transplanted within the experimental plots. The growth and mortality of these seedlings will be measured annually and over a range of plant-organization scales. The data on growth and mortality will be used to calibrate species-specific models of plant performance as a function of nitrogen, calcium, water, and light availability. The growth and mortality models will be coupled to an existing model of forest dynamics (SORTIE). Model simulations will track the change in species composition and successional dynamics of these forests in response to the predicted, human-driven changes in nitrogen and calcium availability and precipitation.

2000-00700 Role of Canopy Gaps and Downed Woody Material in Maintaining Biodiversity in the Acadian Forest of Maine

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Grant 00-35101-9239; $260,000; 3 Years

Current recommendations for maintaining biodiversity in managed forests include (1) designing harvest treatments that mimic natural disturbances and (2) retaining biological legacies in the form of deadwood after harvesting. Two components of forest structural diversity -- canopy gaps and downed woody material (DWM) -- are thought to be particularly important for maintaining biodiversity and long-term productivity of forest ecosystems. When managing canopy gaps and DWM, it is currently assumed that an increase in structural complexity leads to an increase in species richness, however these assumptions have not been tested together in a well-designed experiment. To test these assumptions, we are examining the influence of canopy gaps and DWM on understory vegetation, insects, and amphibians. We are testing three specific hypotheses using an established, long-term study on the Penobscot Experimental Forest in southeastern Maine: (1) characteristics of canopy gaps [gap size, gap origin (harvest or natural), and location within gap] influence the diversity of understory vegetation and insect communities, as well as the numbers and attributes of amphibians; (2) characteristics of DWM (decay class, species, and structural complexity) influence the diversity of insect communities, and the numbers and attributes of amphibians; and (3) predation by amphibians influences the abundance and composition of insect communities, and these interactions are affected by the characteristics of DWM. Understanding these relationships will promote the development of forest management approaches that can maintain biodiversity while satisfying society's increasing demand for wood production.

2000-01280 Dynamics of Climate, Fire and Land Use in the Greater Yellowstone Ecosystem

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Seed Grant; Grant 2001-35106-09864; $65,000; 2 Years

In the Greater Yellowstone Ecosystem (GYE), fire exclusion during the 20th century has resulted in substantial changes in forest structure in the lower forest zones. With funding from this project, I will initiate research on the pre-20th century fire regime of the Douglas-fir forests of the GYE. The spatial and temporal variability of fire in these forests, which range in elevation from 2000 to 2500 m, is poorly known. Specifically, I propose to address the following questions: How significantly has 20th century fire exclusion reduced fire frequency? What was the spatial and temporal variability of pre-20th century fire? How did climatic variability affect pre-20th century fire regimes? How significantly has 20th century fire exclusion changed the aboveground carbon pool?

Pilot data and preliminary results developed with seed grant funding will form a strong base for further competitive funding by: (1) Demonstrating the degree to which fire has been an important ecosystem process in the lower forest zones of the GYE; (2) Identifying the nature of the historic range of variability within this system, and thereby defining an optimal strategy for ecosystem management in the context of a variable environment; and (3) Refining techniques for characterizing changes in aboveground carbon over the past 100 years.

2000-00609 Mandated Nitrogen Loading Reductions to the Hydrodynamically Variable Neuse River Estuary, NC: Implications for Phytoplankton Community Structure and Broader Scale Ecosystem Dynamics

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Grant 00-35101-9281; $324,000; 3 Years

Eutrophication and associated declines in water quality in the Neuse River Estuary, NC have been linked to growing inputs of non-point source nitrogen (N), half of which are of agricultural origin. In response to public concern, a 30% reduction in N loading to the Neuse Estuary was legislatively mandated to be in place by 2003. General agreement exists that such a reduction is appropriate, but the ecological ramifications are unknown. Our prior USDA-supported research indicates that the timing and magnitude of N inputs are strong determinants of ecosystem response to N loading. Using a complementary combination of experimental and field-based research, we will examine potential impacts on ecosystem structure and function at the base of the food web. This will allow us to better predict short and long term ecosystem responses to the proposed nutrient reductions. Overall, our work will yield a better understanding of, and rationale for, evaluating nutrient management strategies designed to reverse eutrophication and restore natural ecosystem function to estuarine ecosystems experiencing excessive nutrient loading.

2000-00610 Long-term Ecosystem Dynamics in a Semiarid Rangeland: Analysis of Historical USDA Data (1915-1999) and a Modeling Synthesis

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Grant 00-35101-9239; $300,000; 3 Years

Many arid regions of the globe have undergone dramatic changes in vegetation during the last century. In the southwestern United States this is exemplified by the large areas of semiarid grasslands that have been virtually replaced by arid shrublands during the last 150 years, such as in the Jornada Basin in southern New Mexico. If further changes in the transition between grassland and shrubland are to be correctly predicted-or if we wish to intervene and redirect transitions-we must develop a greater understanding of the factors that control ecosystem structure and functioning in arid rangelands. One of the unique features of the Jornada Basin is the quantity and quality of long-term data that document vegetation dynamics in a number of different plant communities, on different soil types, in different landscape positions and under various grazing/management schemes over various periods of time from 1915 to the present. We will carry out intensive statistical and computer modeling analyses of these data to examine the following general question: To what extent has variation in weather and climate influenced rangeland ecosystem function within a landscape that is composed of different geomorphic surfaces, land-use patterns (e.g., cattle grazing), and vegetation types? These data sets are among the most extensive in terms of number of species, locations, sampling points, and length of monitoring period of any rangeland in the world. As such they offer a unique opportunity to investigate the role that climate has played in the dynamics of this semiarid rangeland.

2000-00760 Carbon Dioxide Induced Changes in Belowground C and N Cycling in Grasslands

Gill, R.A.
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Postdoctoral Fellowship; Grant 00-35101-9362; $90,000; 2 Years

This proposal addresses the interaction between atmospheric CO_2 concentrations and belowground carbon and nitrogen cycling. Many important plant and soil processes may have been altered because of changes in atmospheric CO_2 since the last ice age, with the possibility that these processes will continue to change with future increases in atmospheric CO_2. My research will: (1) measure the response of root litter chemistry to plants exposed to a range of CO_2 concentrations; (2) determine the potential of grassland soils to store anthropogenic CO_2 in soil carbon pools with long residence times; and (3) determine how changes in plant chemistry interact with microbial populations to influence nitrogen availability for the entire system. I will measure the amount of carbon and its allocation among various fractions of organic matter in a Blackland Prairie that has been exposed to a gradient of CO_2 concentrations since 1996. In addition, the abundance of secondary chemicals in roots will be determined on native plants grown in both a field and a controlled environment experiment where atmospheric CO_2 is manipulated. Finally, nitrogen fluxes in the Blackland Prairie will be measured over a two-year period to see how tightly coupled the carbon and nitrogen cycles are in this ecosystem. By addressing the mechanisms underlying feed backs between plants and soils in controlling C and N cycling, this study will improve our understanding of ecosystem processes that have and may continue to be modified as a consequence of changes in atmospheric CO_2 concentration.

2000-00628 Efficient Methods For Assessing Coarse Woody Material in Forest Ecosystems

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Strengthening Award; Grant 00-35101-9351; $184,000; 3 Years

Coarse woody material (CWM) is an important component of forest ecosystem structure and function, but field methods for its assessment have not been adequately tested. This project will test two established methods (fixed area plots and line intersect sampling) and two novel methods (transect reiascope sampling and point reiascope sampling) across a wide range of forest conditions in the northeastern United States. All four methods are theoretically unbiased, meaning that on average they should give correct estimates for numbers, sizes, and total volume of downed CWM. However, bias may occur under field conditions. This project will test the conditions for and severity of bias using the four methods. Sampling efficiency (accuracy as a function of effort expended) will also be assessed. Methods for assessing standing CWM (snags) will also be tested. Concrete, practical recommendations for field implementation will be formulated. By overlaying the measurements on established silvicultural experiments, specific hypotheses about the relationship of CWM abundance to forest type, size or age, silvicultural system, and management history can be experimentally tested. Software for analyzing CWM data will be developed and made freely available, and a continuing education workshop will be conducted for foresters and other natural resource professionals. The project will enhance sustainability of the U.S. forestry sector by providing tested tools for assessing CWM, and improved characterization of CWM in managed forests.

2000-00698 Interactions of Roots and N in Controlling Redox Chemistry of Riparian Wetlands

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Grant 00-35101-9309; $250,000; 3 Years

Riparian wetlands are widely promoted for their ability to reduce agricultural nitrogen inputs to surface waters. Although the chemical reactions that lead to the loss of N are well known, the relationship of these reactions to wetland vegetation is poorly understood. We propose that there are multiple interactions between plant root systems and the sediments which can affect this chemistry, so that the distribution and dynamics of roots will affect the fate of agriculturally-derived nitrogen. Nitrogen additions may also affect root growth and abundance, however. We thus hypothesize that sediment chemistry will vary both with added nitrogen, with differences in the abundance and dynamics of roots, and with the interactions between the nitrogen and the roots.

We propose field studies coordinated with the construction of a mathematical model to describe the effect of roots on sediment chemistry. Plots established in two forested riparian wetlands within an agricultural landscape will be instrumented and sampled to monitor root dynamics, soil saturation, soil and porewater chemistry and trace gas production. Additions of nitrate and removals of vegetation will be applied in a completely crossed design, and experiments will be conducted to test specific

mechanisms of interaction (e.g., transpiration-induced changes in sediment aeration, competitive uptake of N by the plants). A predictive model describing the sequence of redox reactions and predicting redox potential will be developed to specifically include parameters describing the effects of the roots. The results will provide novel, fundamental information about using riparian wetlands for agricultural pollutant removal.

2000-00629 Relationships among Rangeland Vegetation Community Structure, Wind Erosion Processes, and Ecosystem Degradation

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Grant 00-35101-9310; $177,700; 2 Years

Rangelands in the southwest United States support an important livestock industry. Studies have shown that these ecosystems are vulnerable to drought and poor management leading to progressive and apparently irreversible changes in plant composition and distribution. These changes reduce productivity and can cause the rangelands to become susceptible to wind erosion, leading to desertification. This research is aimed at increasing our understanding of the role of rangeland vegetation in controlling wind erosion. To accomplish this a field study will be carried out to determine how the vegetation, in terms of its type, ability to absorb energy from the wind, and distribution pattern, controls the amount of wind energy reaching the bare soil between the plants. New instrumentation will be used to measure for the first time, the amount of energy absorbed by the plants from the wind and the energy acting upon the bare soil. The field study data will be used to test a model developed to predict how the wind energy is partitioned between the plants and the bare soil surface. We will assess how this model may need to be modified to more accurately represent the effects of specific rangeland plant types. Having a model that predicts how rangeland vegetation controls the amount of wind energy available to cause erosion will allow managers to assess wind erosion susceptibility of an area and develop remediation plans to maintain or enhance stability of these important areas against wind erosion.

2000-01284 Wetland Plant Diversity: A Mechanistic Response to Phosphorus Heterogeneity

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Postdoctoral Fellowship; Grant 00-35101-9373; $90,000; 2 Years

Nutrient availability is a major factor in determining species composition of plant communities. Understanding the controls of species richness in wetland systems is critical to the preservation of species diversity and maintenance of a rapidly diminishing habitat. Rich fens (those high in cations) of central New York are especially species rich. Many of these wetlands have yet to exhibit the characteristic shift in vegetation to domination by an aggressive species such as cattail, despite high inputs of atmospheric and agricultural nitrate.

Phosphorus, rather than nitrogen, may control plant community structure in fens. Because these wetlands receive high inputs of ground water rich in dissolved cations such as calcium and magnesium, phosphorus tends to be tied up in relatively insoluble

geochemical pools. This geochemical buffering of phosphorus maintains resource heterogeneity which, in turn, may regulate species diversity. As phosphorus often limits productivity in these rich fens, many plant species have developed mechanisms for obtaining phosphorus through fungal symbiosis, excretion of chemicals that release phosphorus, and direct uptake of organic phosphorus.

This study tests the hypothesis that plant species diversity in rich fens is maintained by low levels of available phosphorus coupled with the presence of species that are mechanistically able to access mineral-bound and organic forms of phosphorus. I will manipulate soil pools in two rich fens through direct addition of labile, mineral-bound, and organic forms of P, measure nutrient changes in soil-nutrient pools and plant tissue, and compare changes in plant primary productivity and community composition of the different treatments.

2000-01205 Effects of an Invasive Exotic Parasite on Forest Composition and Productivity

Lewis, J.D.
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Seed Grant; Grant 2001-35106-09867; $48,355; 2 Years

Introduction of non-native parasites is a significant threat to native forests. In the eastern Unites States, invasive parasites have virtually eliminated the American chestnut (*Castanea dentata*) and led to extensive decline in other tree species. Currently, forests from North Carolina to Massachusetts are experiencing dramatic declines in eastern hemlock (*Tsuga canadensis*) associated with the invasion of the hemlock woolly adelgid (HWA; *Adelges tsugae*), a non-native insect. Eastern hemlock apparently has no natural defenses to the HWA, and the HWA readily disperses to unaffected stands. Because eastern hemlock is a widely-distributed, dominant, late-successional species, the extent of hemlock loss may parallel the loss of the American chestnut earlier this century. However, because the relative contribution of hemlock to forest composition varies widely at both local and regional scales, ecosystem responses to hemlock decline are likely to vary both within and between communities. This study examines how the relative dominance of hemlock regulates the effects of the HWA on forests by tracking changes in species diversity and aboveground net primary production (ANPP) in hemlock-dominated, hemlock-hardwood, and hardwood forests.

2000-01265 Effects of Cultivar Type on Methane Production from Acetate in a Rice Paddy Ecosystem

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Seed Grant; Grant 2001-35106-09865; $60,000; 2 Years

Emissions of the greenhouse gas methane (CH_4) from rice agriculture have potential for mitigation. Under identical growing conditions substantial differences in total CH_4 emission between rice cultivars have been observed. To date only a small number of studies have investigated the causes for these differences on an ecosystem process level. It is poorly understood how contributions from the two pathways which produce methane, acetate fermentation and reduction of carbon dioxide (CO_2), change

during the growing season and with sediment depth, and the factors which ultimately determine which pathway will predominate and to what extent. This study will address these questions. Two rice cultivars commonly grown in the U.S., Mars and Lemont, will be grown in a greenhouse to allow for the addition of an inhibitor of methanogenesis to be added to experimental plots. Measurements of acetate concentration in the soil will reflect total acetate available for CH_4 production and corresponding data from control plots will be used to determine acetate utilization. Measurements of CH_4 and CO_2 concentration and stable isotope ratios of carbon in CH_4 and CO_2 in sediment pore water at graduated depths and in emitted gases will be made. These measurements will be used to establish the relative contribution from each production pathway and to calculate the percentage of produced methane which is oxidized to CO_2 prior to emission. Throughout the growth period, root exudate levels will also be monitored. The extent to which acetate availability and utilization, methanogenic production pathway, and rhizospheric oxidation are dependent on cultivar type will be evaluated.

2000-00764 The World's Largest Wetlands

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Conference; Grant 00-35101-9359; $7,000; 1Year

Wetlands perform very important functions in our environment. They have been described as the kidneys of the landscape because of their effect on hydrological and chemical cycles, and because they receive downstream wastes from both natural and human sources. They have been found to cleanse polluted waters, prevent floods, protect shorelines, and recharge groundwater aquifers. Wetlands are also referred to as biological supermarkets for the numbers of species (biodiversity) and abundance of biomass they support. They play major roles in the landscape by providing habitat for a wide variety of flora and fauna. These generalizations apply whether one is describing the bottomland hardwoods of the Mississippi River Valley, the Pantanal in South America or the Sudd wetlands of the Upper Nile in Africa.

In the United States, the building of dikes and drainage ditches over the last two centuries has resulted in the loss of 30% of the nation's wetlands, 53% excluding Alaska. International loss of wetlands is not so well documented, but wetlands are under constant threat from agricultural/urban development, deforestation, human water use, and global climate change.

We are assembling 12 experts knowledgeable on the world's largest wetland ecosystems to exchange and share their understanding of the ecological dynamics and conservation of these significant systems. This conference will be held at the Quebec 2000 Wetlands Millennium Event, as part of Intecol 2000, in Quebec City, Canada, August 6-12, 2000.

2000-00748 Developing a Method to Predict Regional Patterns of Biological Nitrogen Fixation

Hicks, W.T.
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Postdoctoral Fellowship; Grant 2001-35101-09876; $90,000; 2 Years

Nitrogen is an important nutrient regulating plant growth and decomposition, yet we have not developed accurate regional estimates of biological nitrogen inputs. As in many regions, nitrogen is a limiting nutrient to tree growth in the Pacific NW. Globally, humans have approximately doubled terrestrial nitrogen inputs producing beneficial as well as severe and long-term consequences. Understanding changes at the global level requires accurate assessment of regional nitrogen cycling. The objective of my research is to create a spatially explicit biological nitrogen input budget for the Pacific Northwest. This will be based on previous research on the activity and distribution of the nitrogen fixing organisms. Extensive research has been conducted on the physiology and rates of nitrogen fixation in lichens, plants such as *Alnus* or *Ceanothus*, and asymbiotic microorganisms in woody debris, soil, and litter. With some minor modification, existing work with spatial models, regional inventory databases, and remote sensing can be used to determine relatively accurate distributions and biomass of lichens, *Alnus*, *Ceanothus*, and woody debris. By coupling the data on abundance and activity of nitrogen fixers, models can be developed to estimate nitrogen fixation rates and how this process will respond to change in key "driving" variables such as climate and land use allowing me to answer the following questions: (1) How do the different nitrogen fixers compare in terms of total and subregional input? (2) How might future changes in climate affect biological nitrogen inputs? (3) How have humans, through land use and management, altered biological nitrogen inputs?

2000-01134 Land-Use and Nutrient Cycles: Exploring Links with a Carbon-Nitrogen Analyzer

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Universidad Metropolitana; Department of Science and Technology; San Juan, PR 00928
Equipment Grant; Grant 2001-35106-09877; $32,114; 1 Year

With the carbon-nitrogen analyzer, plant and soil samples from forests in California and Puerto Rico will be analyzed for concentrations and amounts of carbon (C) and nitrogen (N). The overall goal of my research is to address the effect of past and future changes in land-use on the dynamics and storage of C and N. Land-use change in both regions has resulted in human-modified ecosystems with altered plant species compositions and nutrient cycles. These changes may have considerable consequences for C storage and soil emissions of greenhouse gases, such as carbon dioxide and nitrous oxide. In Puerto Rican humid forests my students and I are measuring the effect of hurricane-induced defoliation on fluxes of nitrous oxide and soil N transformations. We are also examining the effect of litter quality and soil fertility on leaf decomposition, an important ecosystem process in post-agricultural secondary forests. In California mixed-conifer forests and elsewhere in the west, natural fires have been suppressed for decades. There, I am working with colleagues to understand how forest restoration techniques, such as burning and tree removal, affect the spatial relationships among vegetation and soil processes. With the carbon-nitrogen analyzer (LECO CN-2000) I will be able to quantify total amounts of C and N in litter, soils and vegetation for these related projects. This will provide key data to better understand the links between land-use, disturbance and cycles of C and N in two contrasting and significantly modified environments.

2000-00622 Experimental Study of Bird and Arthropod Response to Bottomland Hardwood Gaps

Kilgo, J. C.; Smith, W. P.; Hanula, J. L.
USDA Forest Service; Southern Research Station, Center for Forested Wetlands Research; Charleston, SC 29414
Grant 00-35101-9307; $215,000; 3 Years

Southeastern floodplain forests ("bottomland hardwoods") represent an important natural resource, both from timber and ecosystem diversity perspectives. Timber harvest in bottomland hardwoods is projected to increase during the next 30 years, while acreage in bottomland forest production is projected to decrease. Bottomland hardwoods represent important habitat for many plant and animal species, including numerous migratory birds. Although clear-cutting is the preferred harvesting method in bottomland hardwoods, it negatively impacts habitat quality for some species. Identification of sustainable forest management strategies that simultaneously allow revenue-generating timber removal and enhance (or at least do not negatively affect) wildlife habitat quality is critical for bottomland hardwood forests. Group selection timber harvesting is a silvicultural practice that entails the removal of a group of trees such that a gap is created in the forest canopy. Such gaps are intended to mimic gaps created through natural disturbance processes, such as wind fall, to which native flora and fauna are adapted. We hypothesize that variation in bird diversity and abundance among gaps of various sizes (from 0.3-1.2 acres) and among seasons will be associated with patterns of insect abundance in the gaps, which will, in turn, be associated with patterns of plant structure and diversity. Accordingly, this research is designed to determine the relationships among harvest gap size, plant structure and diversity, and the abundance, diversity, and distribution of insects and birds. We will also evaluate the effect of gap size and insect abundance on reproduction of a representative forest bird, the Hooded Warbler (*Wilsonia citrina*).

2000-00752 Climate Change, Grass Invasions, and Woody Plant Dynamics in Semi-Arid Savannas

Weltzin, J.F.; Williams, D.G.
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Grant 00-35101-9308; $300,000; 3 Years 6 Months

Coincident with a world-wide increase in the abundance of woody plants within former grasslands, grasslands throughout the southwestern United States have experienced a substantial increase in the abundance of mesquite (*Prosopis*) within the last century. These changes in grassland structure have had important implications for the sustainability of local economies and biological diversity. However, many mesquite-dominated grasslands have themselves been recently invaded by the African grass Lehmann lovegrass (*Eragrostis lehmanniana*). Invasions by this grass may change the availability of soil resources (water, nutrients), and thus shift mesquite shrublands back towards grassland. However, these grasslands would be dominated by a non-native grass with arguably greater impacts on ecosystems than mesquite has had on former grasslands.

When predicting how southwestern rangelands might respond to grass invasions, we must also consider potential changes in climate (e.g., changes in precipitation), as

well as soil characteristics (e.g., clay content). We hypothesize that the future establishment of woody plants within these rangelands will depend on soil water dynamics mediated by the identity of neighboring grasses and soil properties. We will experimentally alter native and non-native grass cover and seasonal precipitation at field sites with soils that have different degrees of clay horizon development. The response of mesquite introduced as seeds into experimental plots will be used to gauge the potential recruitment of this species under different environmental conditions. Results from this project will facilitate predictions about the consequences of climate change and non-native grass invasions on proliferation of woody plants in the southwestern United States.

2000-00787 Productivity and Structure of a Coastal Wetland: Fluctuating Freshwater Inflow

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Grant 00-35101-9275; $215,000; 3 Years

Coastal wetlands have enormous ecological, environmental and economic value because they provide habitat for fish and wildlife, protect water resources, allow control of flood and storm water, and are areas of recreation. Increasing demand for freshwater by agriculture, cities and industry has led to damming of rivers and creation of reservoirs, resulting in decreased freshwater flow to coastal wetlands, and a decline in productivity and diversity of plants, algae and plankton. Water management schemes must be developed that balance agricultural demand for freshwater with wetland requirements, but limited information is available on timing and amount of freshwater needed to produce healthy, productive coastal wetlands. The overall objective of this three-year investigation is to determine how productivity and structure of coastal wetlands are affected by fluctuations in freshwater inflow. Tower-based meteorological methods will be used to continuously monitor ecosystem productivity in a coastal wetland in the Nueces River Delta near Corpus Christi, Texas in response to fluctuating freshwater inflow. Tower-based measurements will be combined with more detailed measurements to determine how ecosystem productivity is partitioned among plants, algae and plankton. Results of this investigation will provide information that can be used to optimize water use to sustain both agriculture and coastal environments.

2000-00619 When Does Grasshopper Herbivory Enhance Rangeland Production?

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Grant 00-35101-9267; $200,000; 3 Years

There is debate as to whether foliage-consuming animals enhance plant production by speeding up the rate at which nutrients that limit plant growth are cycled in ecosystems or diminish plant production by slowing down nutrient cycling. Foliage consumption is hypothesized to enhance nutrient cycling and plant production if animals preferentially consume foliage that decomposes more slowly than foliage from other plants in the ecosystem. If animals consume foliage that decomposes more quickly, nutrient cycling and subsequently, plant production will diminish. Severe consumption that reduces plant growth or causes plant mortality will always diminish plant production.

We experimentally examine this proposition using grasshoppers at two North American grasslands (northern Great Plains in eastern Montana and Palouse prairie in western Montana). Grasshoppers are abundant, if not dominant, consumers of foliage in these environments and their densities can be manipulated in enclosed field ecosystems to levels less than, equal to and greater than observed field densities. Within these experimental ecosystems, cycling of nitrogen, the limiting nutrient for plants, plant production and plant species composition will be monitored and related to whether grasshoppers preferentially feed on foliage that decomposes quickly or slowly. This directly tests the above proposition. Furthermore, a survey of sites within the two grasslands will determine how often grasshoppers preferentially feed on faster or slower decomposing foliage, and thereby, potentially enhance or diminish plant production. If grasshoppers frequently enhance plant production then attitudes toward their costly control to prevent losses of livestock forage need reevaluation

2000-00710 Fate of Reactive Nitrogen Derived from Agricultural Sources in Coastal Lagoons

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Grant 2001-35101-09873; $360,000; 3 Years

Coastal lagoons constitute a major type of land margin ecosystem on most continents, yet surprisingly little is known about the impact and fate of nutrients entering shallow lagoons compared to large, river-dominated estuaries. The major source of external nutrients to shallow lagoons is typically groundwater enriched from agricultural activities. Fast-growing benthic macroalgae often proliferate as a result of nutrient over-enrichment, such that macroalgae are the dominant temporary biological sink for nitrogen. We will conduct an interdisciplinary study of watershed nutrient inputs, biological transformations and hydrodynamics within Hog Island Bay, a hallow coastal lagoon located in the Virginia Coastal Reserve, to determine the fate of agriculturally-derived nitrogen entering the lagoon. The research will include: (1) development of a watershed model to relate land use practices to nitrogen inputs in the lagoon; (2) determination of the trophic status of the lagoon and the contribution of different primary producers to nitrogen retention; (3) determination of the fate of organic nitrogen released during macroalgae decomposition (microbial remineralization, coupled nitrification-denitrification, bacterial immobilization); and (4) development of a hydrodynamic model for the lagoon to relate residence time of water parcels to biological transformation rates. The combination of biological process measurements and physical transport models will allow us to link agricultural activities in the watershed to impacts on the structure and function of the coastal lagoon. The results of this research have important implications for understanding and predicting the effects of changing land use on coastal ecosystems.

2000-01130 A Laser Distance Meter-Geographic Positioning System for Spatial Fire Ecology

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Advances in mapping technology are facilitating new approaches to research on the spatial ecology of forests, but some aspects of this topic, such as spatial variation in fire effects, are poorly studied. Variation in fire intensity, for example, affects the patterning of tree mortality and regeneration. This proposal is to improve our laboratory's research infrastructure so that we can more effectively study the spatial ecology of natural disturbances, such as fires, in Rocky Mountain forests. We will acquire a laser electronic distance meter (EDM) combined with a geographic positioning system (GPS). The EDM uses laser technology to allow rapid mapping of features (e.g., trees, burned logs) in a forest. The GPS allows these mapped locations to be converted into real geographic coordinates, using signals from U.S. government satellites. The combination of these two technologies will allow us to accurately map and study details of the spatial arrangement of forests, such as the health of trees, before and after fires. This mapping technology will allow us to study in greater detail, than has been possible until now, how natural and prescribed fires affect the ecology of forests.